Synchronous teaching of ICT courses to virtual classes over the Internet

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Abstract — *This paper describes the setting up, realization and assessment of four experiments which involved the synchronous teaching of four different courses to virtual classes, formed by the use of Internet-based e-learning environments and consisting of students placed at different sites either in the same country or at different countries. The first and the second experiment concerned the delivery of courses on Operating Systems and Computer Networks respectively to students dispersed to different countries. The third and fourth experiments concerned the delivery of courses on High Level Programming and Industrial Informatics to students dispersed within the same university campus but having different motives and educational backgrounds. One of the purposes of all these experiments was to investigate whether existing Internet-based e-learning technology allows the application of modern teaching methods to different types of virtual classes. The characteristic of these modern teaching methods is that they mix theoretical with experimental and collaborative work and develop the meta-cognitive skills of students. By the term Internet-based e-learning environments we refer to a suite of software tools that provide services of interactive oral, visual and written on-line communication of the instructor with students who are dispersed to different sites at different universities and or countries, the electronic presentation of teaching material, the sharing of computer facilities, simulators, virtual labs and the like and the formation of groups of students the members of which are able to interact and communicate between each other. The other purpose was to assess the impact that has on the student's learning process the application of a teaching method of the form just explained above by the use of Internet-based e-learning environment. Each experiment had its unique characteristics by means of which the level of development of the components of conceptualization, problem solving ability and reflectivity of the learning process were assessed. Based on the processing of questionnaires answered by the students, the evaluation of examination results and project work, an assessment of the feasibility of applying a teaching method of the type explained above over the Internet and its impact on the level of learning was made. As collected data indicate, both issues have been positively appreciated.*

Index Terms — *e-learning, synchronous teaching, Internet-based teaching, virtual class*

INTRODUCTION

Judging from some of the work that has been reported in the literature[1]-[5], there seems to be a worldwide effort to test and evaluate different instruction and content delivery paradigms which are based on new pedagogical approaches and the use of e-learning environments that allow the formation of virtual classes consisting of traditional first and second cycle students or non-traditional, multicultural and multidisciplinary students. Among the many pedagogical approaches that are available [6]-[19] and either comprise the current practice or are under consideration, the ones that are based on the constructivist theory of learning [14]-[19] have attracted the attention of many educators. According to this theory there are three components that contribute to the learning process. These are the components of Conceptualization, Construction and Metacognitive actions. Conceptualization involves knowledge and concepts understanding and actions and behaviors interpretation. Construction involves tasks of problem solving in real-life contexts. Metacognitive actions refer to the process of stepping back from the task and reviewing what has been done and experienced. Such a pedagogical approach which introduces functions which are believed to assist in the development of the above mentioned three components has been experimented within the context of this work. Through the execution of four experiments the feasibility of implementing this approach and the influence that has on the components of the learning process was investigated. The four experiments involved (a) the teaching of a course on Operating Systems to a virtual class of students dispersed at three different countries, that is Spain, England and Greece; (b) the teaching of selected topics of a course on Computer Networks again to a multinational virtual class of students placed in England, France, Spain and Greece; (c) the teaching of a course on High Level Programming to a virtual class of volunteer Greek students formed within the University campus and (d) the teaching of a course on Industrial Informatics to the class of students who follow the curriculum of Electrical and Computer Engineering of the Aristotle University of Thessaloniki.

In the Operating Systems course the focus was on the interactivity that an Internet-based environment allows between the students and the instructors and the mixing of the practical work with that of the theory at the same lecturing time. These features are related with the conceptualization component. In the Computer Networks experiment, the focus was on the collaborative work, that is splitting the students to virtual working groups, assigning to each group a project and follow up synchronously the progress of the work of each group. This feature is related with the development of the problem solving ability and metacognitive actions. In the other two experiments the focus was on combining all the features of the considered pedagogical approach to a homogeneous class and not to a multicultural one.

THE PEDAGOGICAL APPROACH

The following principles and guidelines were considered to comprise the basis of a pedagogical approach that aims to improve the conseptualization, construction and metacognition aspects of the learning process.

1. For each topic of the course the learning goals are established and made known to the students
2. Lectures on the concepts and theoretical aspects of each topic are presented by the use of either overhead projector slides, scripts on a blackboard, graphics, animation and display of internet sites.
3. Questions both from the tutor to the students and vice versa are posed by oral and written (e-mail) means, during the presentation of the theoretical aspects of the topic, with the purpose of identifying misconceptions
4. Feedback from the students on the tutor questions is received
5. Questions and comments of students to the tutor and vice versa are made available to all the students
6. The solution of example exercises is demonstrated to the students
7. Computing resources to each one of the students for writing, running and testing programs are allocated
8. Small projects are assigned to groups of students and their work is followed-up by the instructor.

These principles and guidelines were applied to the four courses with differing emphasis on each course.

THE TOOL SUPPORT

For the implementation of the above principles the Learnlinc [20] environment was used and configured to allow an instructor who is residing in one of the sites of the virtual class to control through the use of the appropriate tools the display of his presentation material and the material that he wants to show on the whiteboard, chat orally and textually with the students, pose questions and request feedback from all the students, share program execution applications and watch student assigned project work. Since the operation of the used environment is based on the server/client model of communication, the server part of the software was loaded on a Computer at the Spanish site for the first course whereas the client part of the software was loaded on all the computers of the other sites. Irrespectively of the location of each instructor the entire course was delivered through the Spanish server. Each lecture was recorded and became available to anyone interested, after its completion, through the use of the appropriate tool of the environment. Examination tests upon the completion of each topic were taken and evaluated. The second course was conducted in a similar way. The server part of the software was loaded on a computer at the French site whereas the client part of the software was loaded on all the computers of the other sites. For the other two courses a local server was used.

DESCRIPTION OF THE EXPERIMENTS

First Experiment

The experimental teaching of the course on Operating Systems was decided to take place from October the 1st, 2002 to January the 15th, 2003. Twenty students from Spain, England and Greece formed the virtual class. The agreed schedule of the course is shown in Table 1. The students were selected from those who were eligible to attend the regular course on Operating Systems which was delivered independently at each one of the three universities as part of their curriculum and they were requested to attend the experimental course instead. The performance, reactions and opinions of the ten Greek students who participated in the experimental teaching were recorded. The selection of the ten Greek students was based on their performance on already examined courses such as applied mathematics, programming, computer architecture and data structures. From the ten students, three were selected to have grades at the top of the grading scale (9-10), the other three

#	Dates	Subject	Teacher
01	Sep. 30 - Oct. 4	Introduction/C Programming	Prof. G. Hassapis Prof. V. Alexandrov
02	Oct. 7 - Oct. 11	Process Model	Prof. Abelardo Pardo
03	Oct. 14 - Oct. 18	Process Model	Prof. Abelardo Pardo
04	Oct. 21 - Oct. 25	Process Scheduling	Prof. Abelardo Pardo
05	Oct. 28 - Nov. 1	Process Scheduling	Prof. Abelardo Pardo
06	Nov. 4 - Nov. 8	Inter Process Communication	Prof. G. Hassapis
07	Nov. 11 - Nov. 15	Inter Process Communication	Prof. G. Hassapis
08	Nov. 18 - Nov. 22	Inter Process Communication	Prof. G. Hassapis
09	Nov. 25 - Nov. 29	Memory Management	Prof. G. Hassapis
10	Dec. 2 - Dec. 6	Memory Management	Prof. G. Hassapis
11	Dec. 9 - Dec. 13	File systems	Prof. Abelardo Pardo
12	Dec. 16 - Dec. 20	Input/Output	Prof. V. Alexandrov
13	Jan. 6 - Jan. 10	Security and Protection	Prof. V. Alexandrov
14	Jan. 13 - Jan. 17	Distributed Operating Systems	Prof. V. Alexandrov
15	Jan. 20 - Jan. 24	Distributed Operating Systems	Prof. V. Alexandrov

TABLE 1
SCHEDULE OF THE OPERATING SYSTEM COURSE

at the middle of the scale (6-8) and the remaining students at the low part of the scale (5-7). By selecting students on the basis of these criteria, a representative sample of a typical class of students that attend an Operating Systems course in Thessaloniki was formed.

Second Experiment

The second course involved the experimental teaching of selected chapters of the Computer Networks topic and it was decided to take place from March the 5th until April the 9th , 2003 The agreed schedule of the course is shown in Table 2.

Five students from each one of the participating universities were selected to attend this course. The participating universities were tye University of Reading, UK, the University Carlos II of Madrid, Spain, INSA of Lyon, France and the Aristotle university of Thessaloniki, Greece. The students were selected from the students who were enrolled in the second cycle of studies at their Departments and expressed an interest in participating in the experiment. The selection of the Greek students was based on their performance on already examined courses such as applied mathematics, programming, computer architecture and data structures. At each session students were divided to groups of 5 persons and project work was assigned

to each group. Each group had its own leader who could liaise with the instructor whereas the group members were able to interact between each other and with the instructor but not with the members of the other groups.

Date	Time(CET)	Topic	Institution
5 March 2003	9:00-13:00	Routing Techniques for Contemporary Networks	Aristotle University of Thessaloniki, Greece
19 March 2003	9:00-13:00	Network Administration Part I	INSA Lyon, France
26 March 2003	9:00-13:00	Network Administration Part II	INSA Lyon, France
2 April 2003	9:00-13:00	GRID Computing	University of Reading, Reading,UK
9 April 2003	9:00-13:00	Web Services and HTTP Protocol	University Carlos III, Madrid, Spain

TABLE 2
Schedule of the Computer Network course

Third Experiment

Teaching the third course was scheduled to take place from March the 12th until May the 15th. The course schedule is shown in Table 3 and was addressed only to students of the University of Thessaloniki.

Date	No of sessions per group	Session duration (hours)	Topic
12/3-31/3	3	3, 3, 2	UNIX/LINUX
1/4-7/4	3	3, 3, 2	MATLAB
10/4-9/5	3	3, 3, 2	Visual C++
15/5-25/5	3	3, 3, 2	JAVA

TABLE 3
SCHEDULE OF THE PROGRAMMING COURSE

The course was aiming to improve the programming skills of students who are at different levels of their studies. For this reason an open call for expression of interest was addressed to all the students of the Department of Electrical and Computer Engineering who are registered in the four last semesters of studies. One hundred and twelve students out of 150 applicants were selected on the basis of the uniformity of their basic background, that is, having passed the same basic courses of the curriculum of the Department on mathematics and computer science. These students were divided to four groups. Each group of students was taught the same lecture at a different date of the week from the other group. Each lecture was recorded and after its completion it was made available to anyone interested through the use of the appropriate tool of the environment.

Fourth Experiment

The fourth course concerned the teaching of the topic of Industrial Informatics to a regular class of 30 students by applying the new pedagogical approach and using the electronic tools. The students of the class were all the students who were enrolled in this course and were obliged to attend it as part of the requirements for obtaining their degree. The course involved first, the presentation of the architecture of the computer systems that are designed to control automatically, monitor the performance and program the operations of industrial processes, such as oil refineries, petrochemical complexes, power stations and the like. Next, the course addressed the issue of configuring and developing application software. As part of the course, the students were requested to carry out practical exercises by using simulators of computer control systems. The contents of the course are presented in Table 4.

No	Topic
1	Information Model of an Industrial Environment
2	Architecture of the Distributed Computer Control System
3	Algorithms and Functions for the Automatic Control of Processes
4	Configuration Environments of Distributed Computer Systems
5	Open architecture Systems-The IEC 61131-3 standard
6	Programming Languages (Ladder Logic Diagrams, Instruction List, Function Blocks, Sequential Function Charts)

TABLE 4
CONTENTS OF THE COURSE ON INDUSTRIAL INFORMATICS

ASSESSMENT

For an evaluation of all the courses, students were asked to complete questionnaires, to take tests, present project work and analyze their experiences. Test results were the answers of the student feedback to instructor's questions asked during the normal flow of each course, examination tests conducted after the conclusion of each course and presentations of project work.

Assessment of the students' view

In the questionnaire the students were asked to grade whether the course delivery in the presented way raises the attendance interest (interest attribute in Tables 5, 6, 7 and 8), how well they think that they learned from the module as far as conceptualization, problem solving and metacognition are concerned (learning attribute in Tables5, 6, 7 and 8) and how satisfactory they found the e-learning technology (environment attribute in Tables 5, 6, 7 and 8) to implement the synchronous collaborative pedagogical approach

Attribute	% of students that gave a grade of				
	1	2	3	4	5
Interest	3.3	6.6	14.7	27.9	47.5
learning	3.3	24.6	42.6	22.9	6.6
Environment	0	1.6	22.9	47.5	27.9

TABLE 5
STUDENT GRADES FOR THE OPERATING SYSTEMS COURSE

Attribute	% of students that gave a grade				
	1	2	3	4	5
Interest	0	0	0	83.3	16.6
Learning	0	0	87.5	12.5	0
Environment	0	0	37.5	62.5	0

TABLE 6
STUDENT GRADES FOR THE COMPUTER NETWORK COURSE

Attribute	% of students that gave a grade of				
	1	2	3	4	5
interest	0	0	37.5	62.5	0
learning	0	3.3	49.2	18	29.5
Environment	0	1.7	35.8	51.7	10.8

TABLE 7
STUDENT GRADES FOR THE PROGRAMMING COURSE

Environment	0	0	40.0	50.0	10.0

TABLE 8
STUDENT GRADES FOR THE INDUSTRIAL INFORMATICS COURSE

Attribute	% of students that gave a grade of				
	1	2	3	4	5
Interest	0	6.7	36.7	33.3	23.3
learning	0	3.3	13.3	56.7	26.7

As one can observe, in all the courses more than 75% of the students had the feeling (grades 3, 4 and 5) that they learn better when the synchronous collaborative pedagogical approach is adopted and implemented over the Internet. More than 90% of the students think that the used present state-of-the-art e-learning environment is adequate to implement the considered pedagogical approach (grades 3, 4 and 5), whereas almost the same percentage of students think that interest in attending the course becomes higher (grades 3, 4, 5) when the course is delivered in this way.

Assessment of the Examination Results

The results of the assessment of the Greek students who participated in each one of the four courses are shown in Tables 9, 10, 11 and 12 respectively. The assessment involved tests with questions that were aiming to assess the achieved level of understanding the critical concepts of the course and project work presentation by each member of the break-out teams for assessing the skills of problem solving and metacognitive actions.

	Level of skill				
Skill	1	2	3	4	5
Conceptualization	0	10	30	40	0
Problem Solving	0	15	75	10	0
Metacognition	5	20	45	25	0

TABLE 9
ASSESSMENT RESULTS OF THE TEST AND PROJECT WORK ON OPERATING SYSTEMS COURSE

	Level of skill				
Skill	1	2	3	4	5
Conceptualization	0	11.1	38.9	50	0
Problem Solving	5.6	16.7	33.3	44.4	0
Metacognition	11.1	22.2	38.9	27.8	0

TABLE 10
ASSESSMENT RESULTS OF THE TEST ON COMPUTER NETWORKS COURSE

	Level of skill				
Skill	1	2	3	4	5
Conceptualization	4.2	7.5	43.3	29.2	15.8
Problem Solving	1.7	1.7	45	48.3	16.7
Metacognition	2.5	1.7	40	53.3	2.5

TABLE 11
ASSESSMENT RESULTS OF THE TEST AND PROJECT WORK ON THE PROGRAMMING COURSE

	Level of skill				
Skill	1	2	3	4	5
Conceptualization	0	6.7	36.7	43.3	13.3
Problem Solving	0	0	60.0	30.0	10.0
Metacognition	0	3.3	40.0	36.7	20.0

TABLE 12

The assessment data indicate that the achieved level of conceptualization and skills of problem solving and metacognition is for all the courses from good (grade 3) to excellent (grade 5) for more than the 80% of the students. In the last two courses excellent performance in conceptualization and problem solving skill is observed for at least the 10% of the students. We considered the achieved performance quite satisfactory as far as problem solving and metacognition is concerned. A comparison of these performance data with data obtained from the conventional delivery of these courses is not feasible because either the assessment criteria in the conventional courses which were delivered in previous academic years are restricted in the evaluation of the level of the achieved conceptualization or the same courses are not included in the curriculum. As far as conceptualization is concerned, the observed performance in the courses of Operating Systems, High Level Programming and Industrial Informatics indicated that the percentage of students that achieved grades in the range of 3-5 seems to be higher by 10-15% from that of the respective conventional course.

CONCLUSIONS

In this work an experimental investigation was made on the feasibility of applying a collaborative pedagogical approach to the teaching of ICT courses to virtual classes of students formed by the assistance of e-learning environments. The learning outcome from the realization of this approach was also assessed. The experiments involved the delivery of four different ICT courses, namely the courses on Operating Systems, Computer Networks, High Level Programming and Industrial Informatics to classes of students ranging from 20 to 30 persons. Depending on the course, the students of each class were dispersed either to sites located at three to four different European countries or to different sites within the same university campus. It has been proved to be feasible to apply over the Internet a pedagogical approach which involved a mixture of lecturing on a topic, carrying out laboratory-like work by the use of simulators, splitting the students to small groups and assigning project work to each group. The grading data collected from questionnaires distributed to the students, examination results and assessments of the project work presentations, indicated that student's feel that delivering a course on ICT with this pedagogical approach and by the use of an e-learning environment raises their interest to attend the course, makes them to understand better the taught subject and improves their problem solving and metacognition skills. Similar conclusions were drawn from the examination results and project assessment, that is for the 80% of the students of each class, irrespectively of the type of the course (more theoretical or more practical) and the composition of the class (students from different countries or students of the same ethnic origin or students with differing educational background), the grades on conceptualization, problem solving skill and metacognitive actions are equal or above the grade that is considered to be good.

ACKNOWLEDGEMENT

Funding for some of this work is from the GENIUS project of the eLearning Initiative program of the European Union, Grant 2001-3450/001-001.

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